Study on the Surface Infiltration Rates of Permeable Pavements

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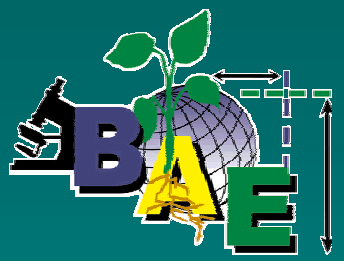


Biological and Agricultural Engineering

NC STATE UNIVERSITY

Objectives

- How well do Permeable Pavements perform?
- Does clogging hinder **SURFACE** infiltration?
- Does maintenance improve infiltration?
  - If so, by how much?
- Is there a Water Quality benefit from Permeable Pavements?

Impervious Surfaces

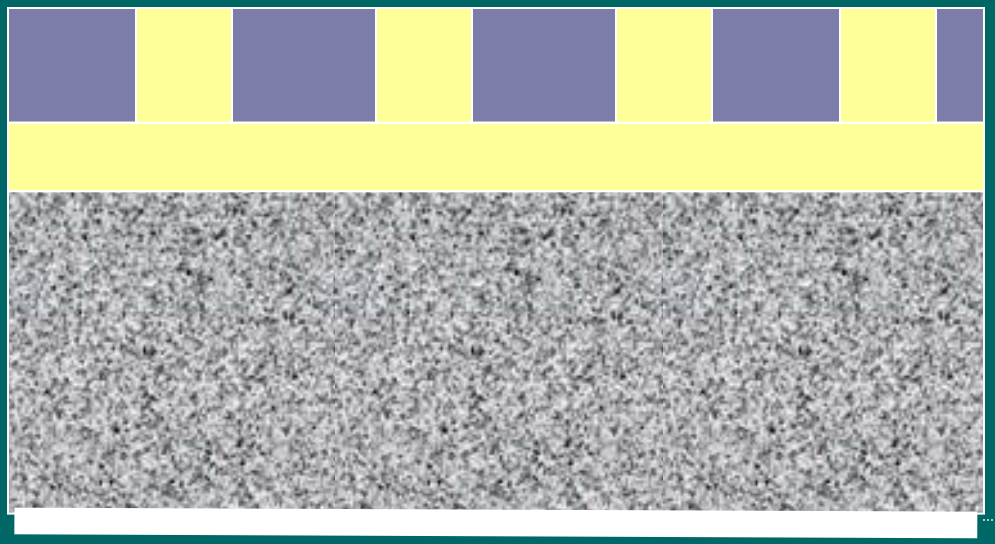
- Increased Total Volume of Runoff
- Increased Peak Runoff
- Downstream Erosion
- Decreased Time of Concentration
- Reduce Groundwater Recharge
- Pollutant Transport
- Water Quality
- Thermal Impacts

Permeable Pavement

- Asphalt or Concrete alternative--some cases
  - Modified Sand Filter
  - Allows infiltration
  - Filters Stormwater

  - Parking Lots
  - Driveways
  - Walkways & Bike Paths

Permeable Pavement



Pavement Layer

Water Storage

Geo-Fabric

In-Situ Soil

Permeable Pavement

- Not yet a Stormwater BMP accepted by the State of North Carolina's DWQ

WHY?

Clogging

- Seals off the surface
  - Sediment deposition
    - Vehicle Traffic
    - Runoff onto surface
    - Bigger problem in clay soils
  - Automotive fluids work like coagulants

UN-Clogging

- Remove clogging material
  - Vacuum Truck
  - Street sweeper
  - Scarify surface
  - Pressure Washing?

Infiltration Rates

- 48 sites
  - NC, MD, DE, VA
  - Concrete Grid Pavers (17)
  - Permeable Interlocking Concrete Pavers (14)
  - Porous Concrete (11)
  - Porous Asphalt (5)
  - Plastic Turf Reinforcing Grids (1)

Procedure

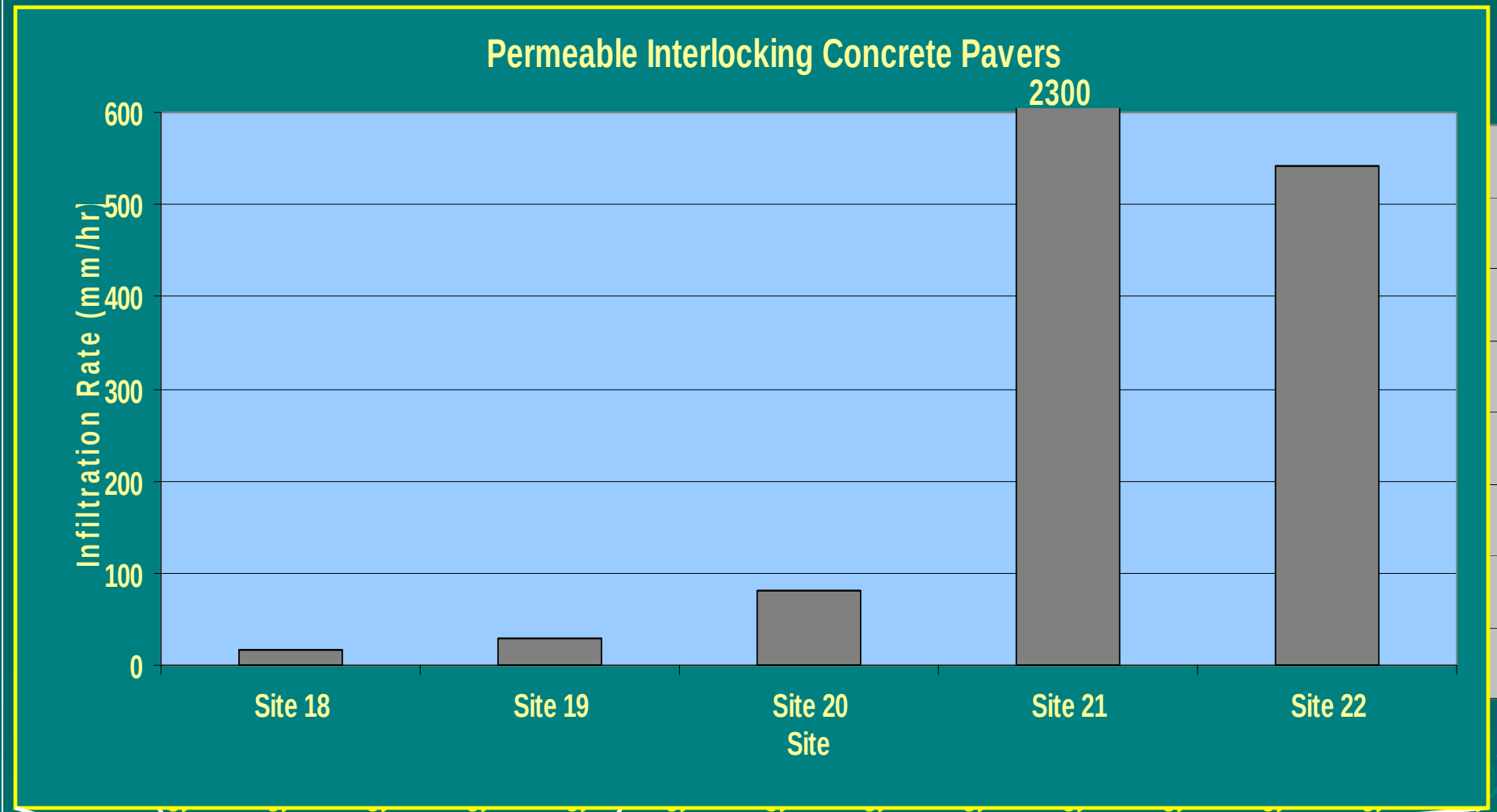
- Modified ASTM D-3385 Procedure
  - Double Ring Infiltrometer

Procedure

- Surface Inundation Test
  - >30 in./hr
  - Single Ring Test
  - Not as accurate as Double Ring Infiltrometer Test
  - Almost all PICP sites
  - Most PC sites

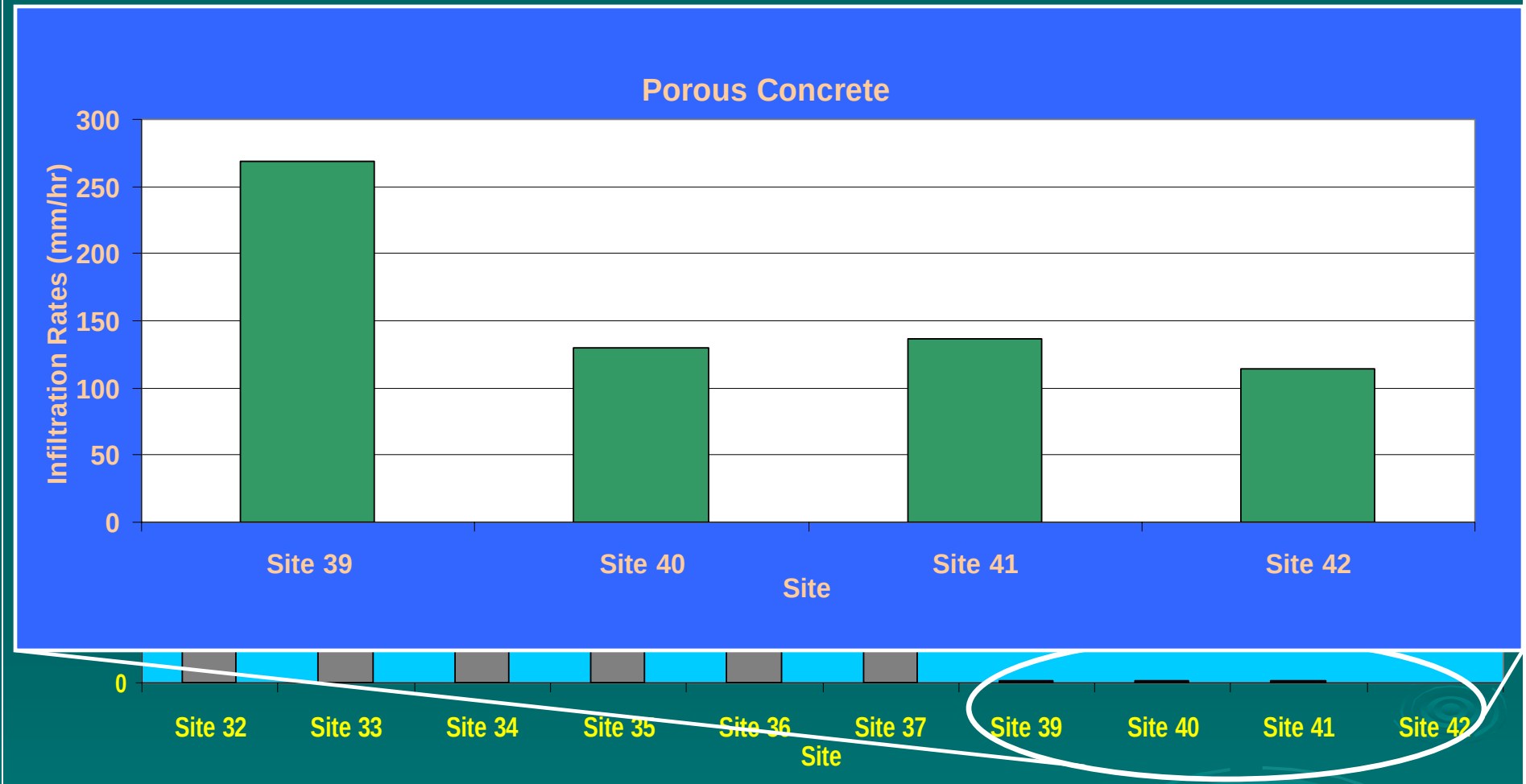
Data

- Surface Infiltration Rate:
  - Slope of water level vs. time
  - Surface Infiltration Rate average of three test runs
    - Existing
    - Maintained


Permeable Interlocking Concrete Pavers
2300
600
500
400
300
200
100
0
Infiltration Rate (mm/hr)
Site 18
Site 19
Site 20
Site 21
Site 22
Site
Site

Location, Location, Location…

- PICP Exposed to Fines:
  K = **80 mm/hr**
  (3.1 in./hr)
- PICP not Exposed to Fines:
  K = **20000 mm/hr**
  (800 in./hr)
- 99% confidence statistically significant difference


Porous Concrete
Infiltration Rates (mm/hr)
300
250
200
150
100
50
0
Site 39
Site 40
Site 41
Site 42
Site
0
Site 32
Site 33
Site 34
Site 35
Site 36
Site 37
Site 39
Site 40
Site 41
Site 42
Site

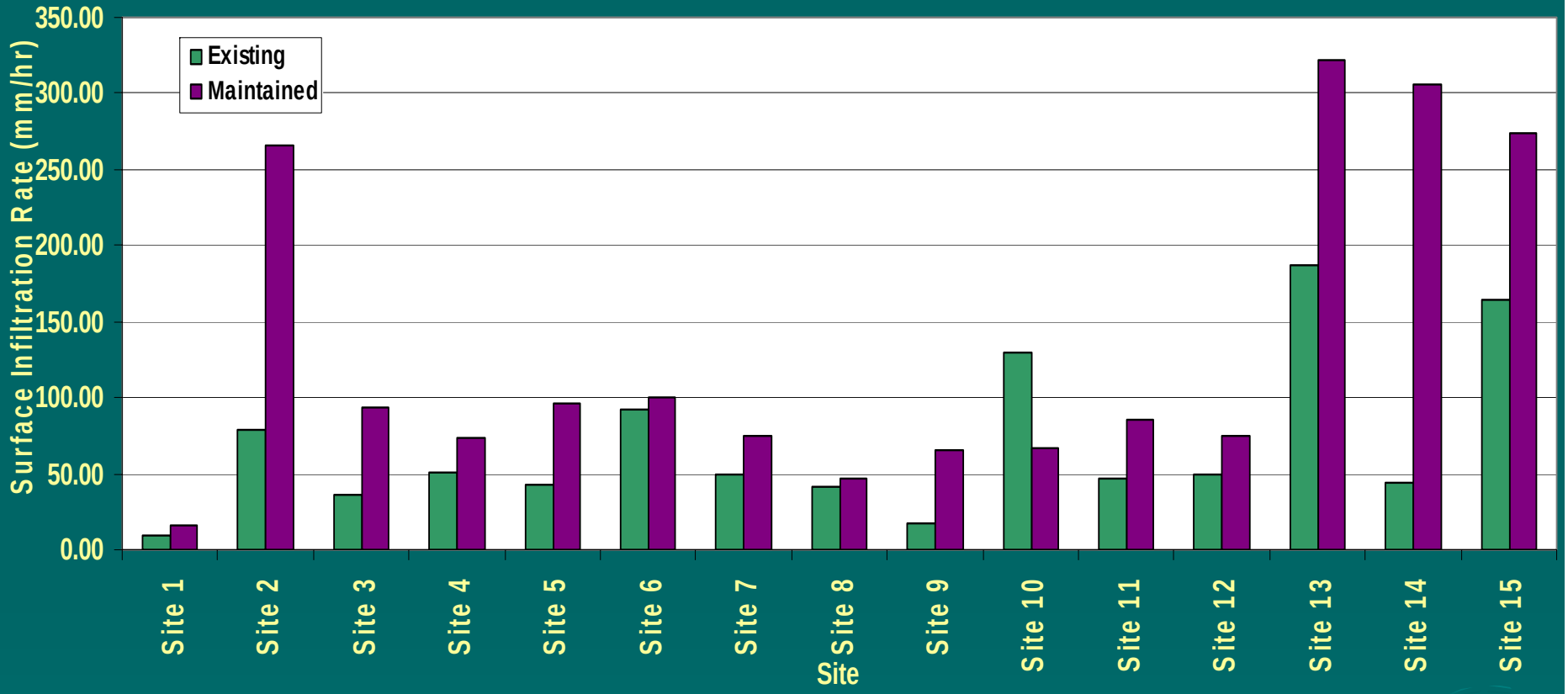
Porous Concrete

- PC Exposed to Fines:
  K = **130 mm/hr**
  (5.2 in./hr)
- PC not Exposed to Fines:
  K = **40000 mm/hr**
  (2000 in./hr)
- 99% confidence statistically significant difference

Maintenance

- Remove top 12 - 19 mm (0.5-0.75 in.) of material
  - Street sweeper
  - Gerrits & James (2002)
- Repeat Test

Concrete Grid Pavers

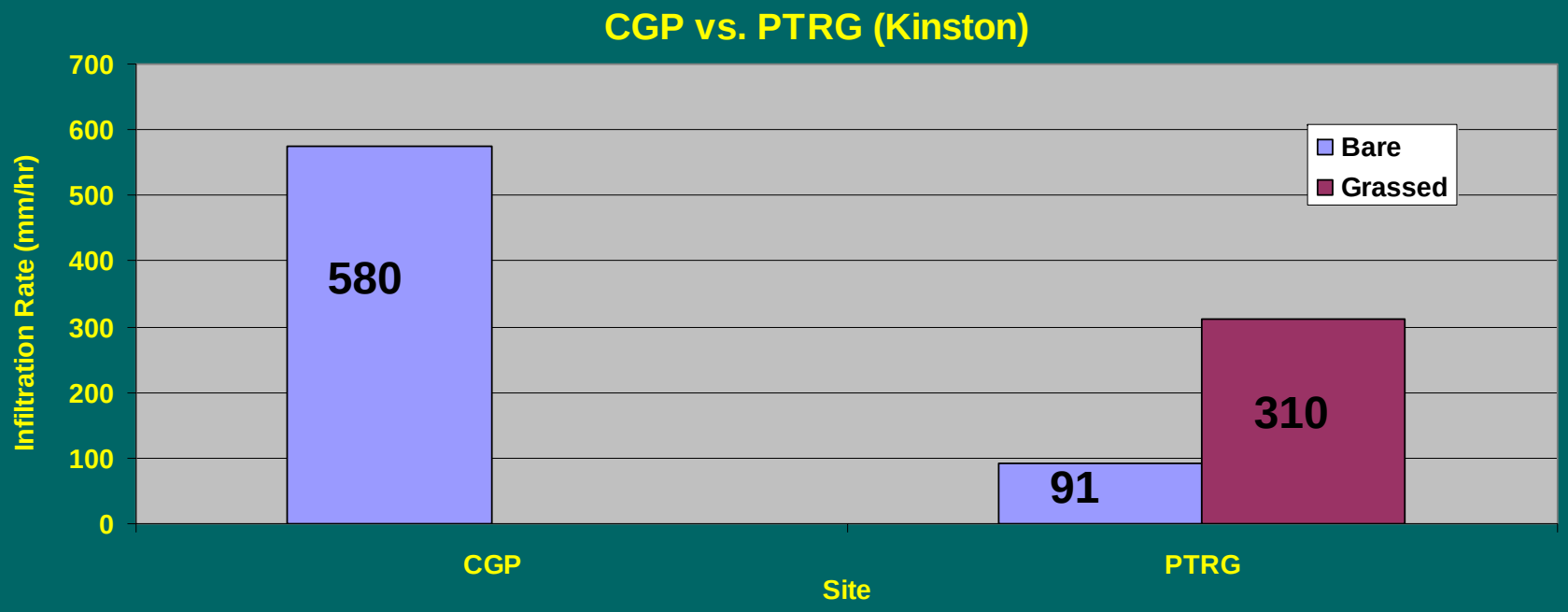


14/15 Sites improved surface infiltration after maintenance

Maintenance

- Existing CGP
  K = 49 mm/hr
  (1.9 in./hr)
- Maintained CGP
  K = 86 mm/hr
  (3.4 in./hr)
  66% increase

- 97% confidence statistically significant difference



- Similarly Used
- Installed at the Same Time
- CGP > PTRG w/ Grass

Results

- Location of PICP
  - Significantly ($p<0.01$) higher infiltration rates away from fines
- Location of PC
  - Sites with fines had infiltration rates significantly ($p<0.01$) lower than areas free of fines

Results

- CGP & Maintenance
  - Maintenance significantly improved surface infiltration rate ($p<0.03$)
- CGP vs. PTRG
  - PTRG had higher infiltration rates with grass
  - higher infiltration rates than PTRG even with grass
- 90% of sites tested had surface infiltration rates of >29 mm/hr (~1 in./hr)

Design Implications

- CGP sites should be maintained on a regular interval
- PICP and PC sites should be constructed in areas free of fines

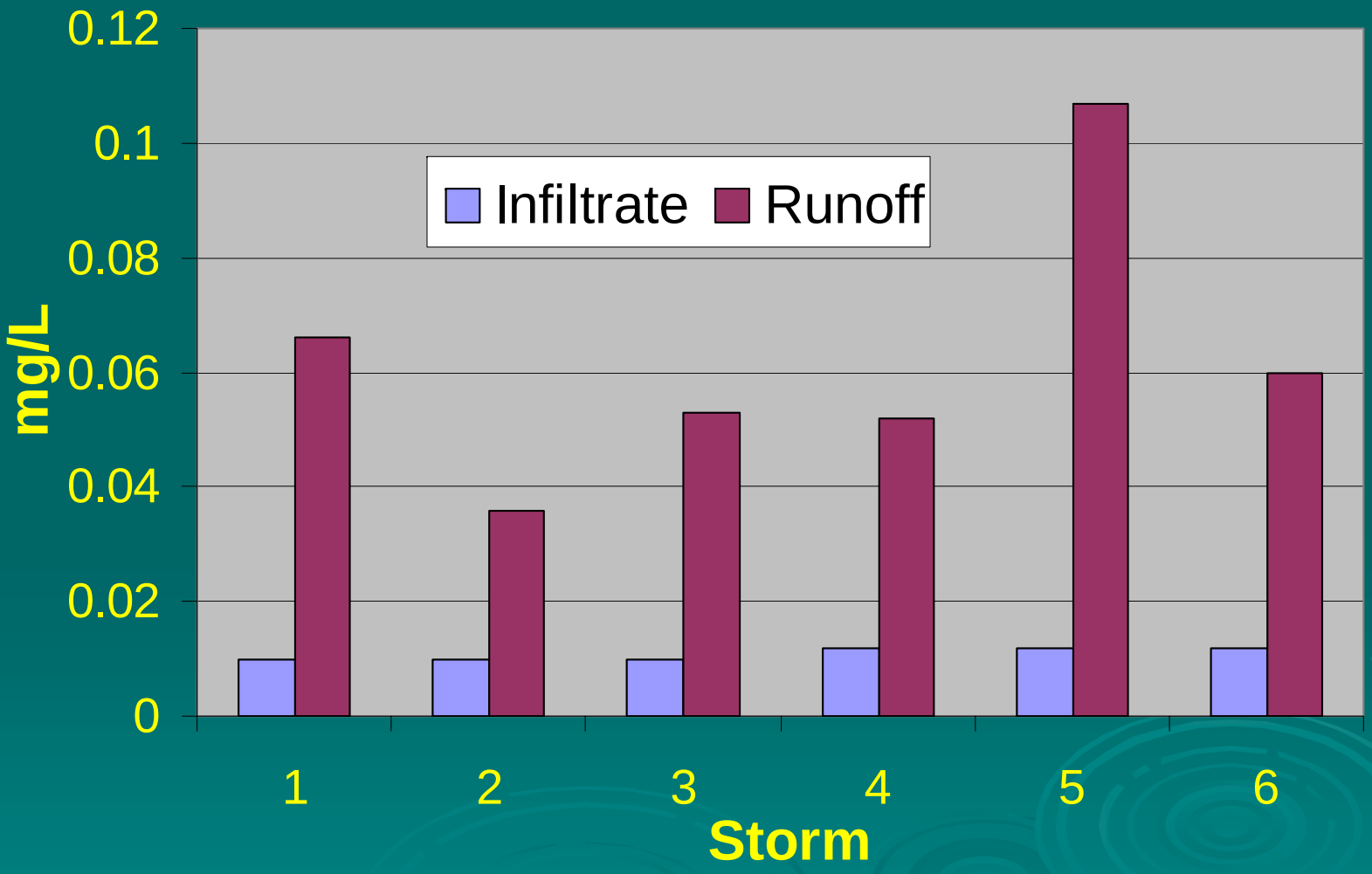
Water Quality Monitoring Sites

- Three PICP Sites (NC):
  - Goldsboro, Swansboro, and Cary
- Infiltrate & Runoff Concentration
- Pollutant Removal

Goldsboro Monitoring Site

- Compare Asphalt Runoff to Infiltrate
  - Metals
  - Phosphorus
  - Nitrogen
  - Total Suspended Solids

Summer ‘03- Fall ‘03 [Zn]



Monitoring Sites

- Swansboro – Public Parking
  - Compare Water Quality of Runoff and Infiltrate of PICP Lot
  - Runoff volume attenuation
- Raleigh – Private Driveway
  - Compare Water Quality of Rainfall and Infiltrate (N & P)
  - Runoff volume attenuation

Thank You

- ICPI
- NCDENR/US EPA 319
- Brandon Eckrote
- Zach Woodward
- Dave Bidelspach
- William Hunt, Ph.D.

Thank You

- Email: eban_bean@ncsu.edu
- Permeable Pavement Website:
  - Current Research Reports and Papers